Asian Journal of Surgery (2018) 41, 356–362

Available online at www.sciencedirect.com

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journal homepage: www.e-asianjournalsurgery.com

ORIGINAL ARTICLE

Surgical treatment of postintubation tracheal stenosis: A retrospective 22-patient series from a single center

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Received 27 December 2016; received in revised form 22 February 2017; accepted 2 March 2017
Available online 12 April 2017

KEYWORDS
postintubation;
tracheal stenosis;
tracheal surgery

Summary *Background/Objective:* We aimed to present cases of postintubation tracheal stenosis (PITS), all due to long-term intubation and treated surgically in a university hospital, and to discuss them in light of the literature.
Methods: In this retrospective study, 22 patients who were treated with tracheal resection and reconstruction due to PITS were included. Demographics, intubation characteristics, localization of stenosis, surgical technique and material, postoperative complications, and survival of patients were recorded.
Results: The mean intubation duration was 16.95 days with a median of 15.00 days. Collar incision was applied in 19 cases (86.4%); in two cases (9.1%) a median sternotomy incision was used; and in the remaining case (4.5%), a right thoracotomy incision was made. The mean tracheal stenosis length was 2.14 cm (mean excision length, 2.5 cm). In 17 cases (77.3%), the anterior walls were supported with vicryl (polyglactin) suture one by one. No postoperative complications were observed in 12 cases (54.5%). No recurrence developed during the long-term follow-up of 15 of the 22 patients (68.2%). Two patients (9.1%) died in the early stages after surgery, and five patients (22.7%) had a stent inserted due to restenosis.
Conclusion: Tracheal resection and end-to-end anastomosis are the most efficient techniques

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http://dx.doi.org/10.1016/j.asjsur.2017.03.001

in cases without medical contraindications, despite emerging stent or endoscopic procedures. Endoscopic interventions can be suggested as an alternative to surgery in patients for whom surgery cannot be performed or who develop recurrence.

1. Introduction

Postintubation tracheal stenosis (PITS) is a clinical condition that frequently occurs due to tracheostomy or long-term intubation.[1] Although its incidence has decreased due to improvements in intensive care procedures, it continues to be a bothersome problem. The rate of tracheal stenosis related to prolonged intubation varies between 0.6% and 21%.[1,2] PITS occurs due to overinflation of the endotracheal tube or the tracheostomy cuff, causing ischemic necrosis due to the pressure in the trachea.[3] The tracheostomy tube may also cause damage to the cartilage or may cause an infection at the edge of the stoma, and granulation tissue may occur accordingly.[1] Although stenosis is usually seen in the tracheal body, it may also be seen in the subglottic region.[4,5]

The symptoms are generally insidious. Most arise 1—6 weeks after extubation, and early symptoms are often not recognized. The most common symptoms include shortness of breath, cough, recurrent pneumonia, wheezing, stridor, and cyanosis over time.[3] Dyspnea is often the symptom until the tracheal diameter is 50% smaller than normal. When the tracheal diameter is 25% of its normal size, dyspnea and stridor may occur even at rest. These symptoms can be confused with other respiratory diseases.[6]

Despite conservative and palliative interventions,[7] the gold standard treatment for PITS, as described by Grillo, is tracheal resection and primary end-to-end anastomosis with reconstruction.[2] In literature, studies were primarily focused on the management of tracheostomy-induced PITS with limited data on the surgical approaches for PITS due to long-term intubation.[5,8,9] To standardize the surgical techniques and optimize the outcome, more experience on PITS due to long-term intubation needs to be published.

Therefore, in this study, we aimed to present the cases of PITS, all due to long-term intubation and treated surgically in our center, and to discuss them in light of the literature. We evaluated these cases with regard to etiology, diagnosis, treatment, recurrence, and fatality.

2. Methods

2.1. Setting and patients

The study was conducted at a 1000-bed university hospital with a well-established and experienced (on tracheal surgery) thoracic surgery clinic.

In this retrospective study, all the patients who were treated with tracheal resection and reconstruction due to PITS between September 2006 and March 2015 were identified consecutively. There was only one inclusion criterion for this study: admission with PITS and treated with tracheal resection and reconstruction (end-to-end anastomosis). Exclusion criteria of the study were (1) tracheal resection due to the traumatic, malign, or benign disease of the trachea and (2) patients with missing data. The study was approved by the Institutional Ethics Committee and conducted in accordance with the ethical guidelines of the Helsinki Declaration. The informed consent was waived for the retrospective design of the study.

The demographics, intubation characteristics, localization of stenosis, surgical technique and material, postoperative complications, and survival were recorded for all patients.

2.2. Preoperative evaluation

All patients were evaluated preoperatively with Hugh—Jones classification, complete routine blood biochemistry, respiratory function test, bilateral chest radiography, lateral neck radiography, and conventional tomography. Patients respiratory performance was varied between Grade 2 and 3 in the Hugh—Jones classification. All patients had fixed upper airway obstruction respiratory function test pattern, which is characterized by flattening of both the inspiratory and expiratory portions of the flow-volume loop. Patients had undergone rigid bronchoscopy and flexible bronchoscopy at least once before the operation, with at least one tracheal dilatation being performed in the operating theater (Figure 1).

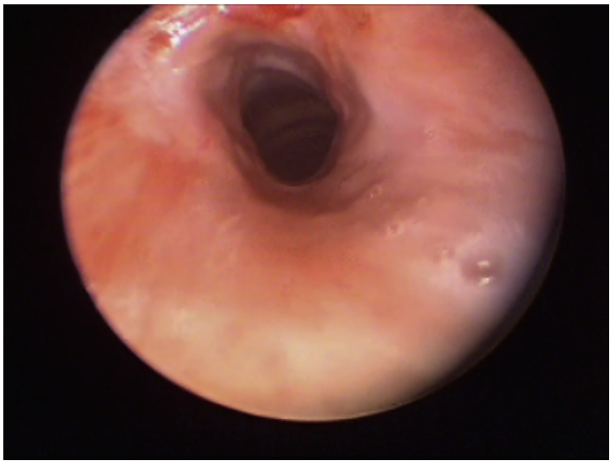

Figure 1 Preoperative rigid bronchoscopy image.

2.3. Surgical technique and postoperative follow-up

The operation technique was applied as described by Pearson et al[10] and Grillo et al[11] in 19 cases where stenosis levels were in the cervical region. Rigid bronchoscopy was conducted in all cases just before intubation, and dilatation was performed during the operation to decrease problems with ventilation. The orotracheal tube was not advanced past the vocal cords but just proximal to the stenosis level. A collar incision was applied to cases in which the stenosis was in the cervical region. The tracheal stenosis region was determined by fiber—optic bronchoscopy and marked during the operation. The trachea was cut horizontally starting at the healthy tissue, and the distal trachea was intubated with a second spiral tube as the orotracheal tube was withdrawn slightly (Figure 2). After the stenotic parts were excised, solid cartilage was detected. The infrahyoid release and cervical flexion maneuvers were used in cervical stenosis, and the tracheal release and hilar release maneuvers were used in distal tracheal stenosis. The end-to-end anastomosis was initiated from the posterior wall. The membranous wall was anastomosed with a continuous suture (vicryl, PDS, PROLENE, and MONOCRYL; Figure 3). In addition, vicryl sutures were used to support the anterior wall. All patients were tested for air leaks after reconstruction, and the operation was completed by placing a perniosis and Mini Vac drain into the operating region. In patients who underwent collar incision, the neck was placed in flexion, and the chin was fixed to the skin tissue on the sternum using a suture. After completing the operation, the anastomosis was monitored by fiber—optic bronchoscopy. All patients were taken to the intensive care unit and extubated postoperatively. Early follow-ups were conducted in the intensive care unit. A median sternotomy incision was added to the collar incision in two cases in which the stenosis was located at the entrance to the thorax. In one case, the right thoracotomy incision was placed close to the carina.

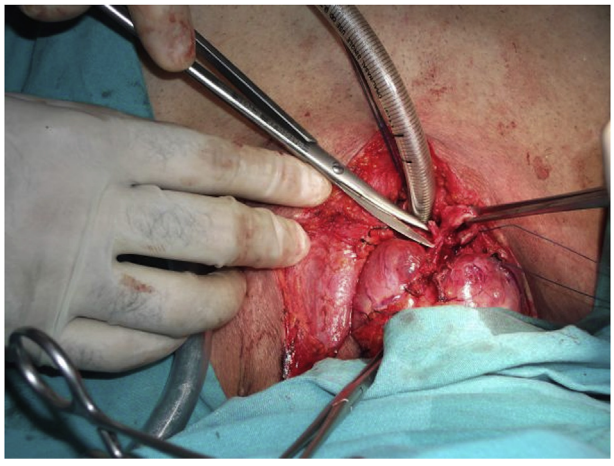

Figure 2 Intubation of distal trachea with a second spiral tube.

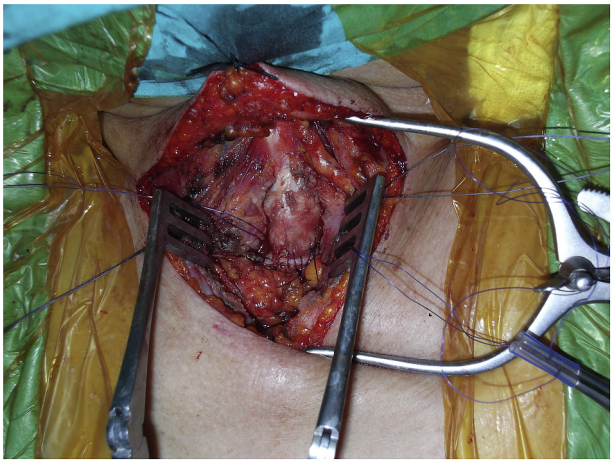

Figure 3 Anastomosis of the membranous wall with a continuous suture (vicryl, PDS, PROLENE, and MONOCRYL).

2.4. Statistical analysis

Mean, standard deviation, median, interquartile range, minimum, and maximum were used as descriptive statistics to summarize study data.

3. Results

3.1. Demographics and clinical findings

Six female (27.3%) and 16 male (72.7%) patients underwent surgery during the study period. While most of the patients (54.5%) were aged between 21 years and 40 years, the mean age of the patients was 34.73 years with a median of 32.50 years. Half of the patients were intubated from 11 days to 20 days, and the mean intubation duration was 16.95 days with a median of 15.00 days. While the most common reason of tracheal intubation was trauma ($n = 12$, 54.5%), the others were surgical reasons (3 post-tracheostomy, 1 post-thyroidectomy; $n = 4$, 18.2%), heart attack ($n = 3$, 13.6%), respiratory arrest ($n = 2$, 9.1%), and cerebrovascular accident ($n = 1$, 4.5%), respectively (Table 1).

The mean distance of stenosis to vocal cord was 3.41 cm with a median of 3.00 cm (range, 1.50—8.00 cm). The mean length of the stenosis was 2.14 cm with a median of 2.00 cm (range, 1.00—4.00 cm; Table 2).

3.2. Operative and postoperative findings

Collar incision was applied in 19 cases (86.4%) because the stenosis level was in the cervical region; in two cases (9.1%), a median sternotomy incision was used as the stenosis reached the level of the thorax; and in the remaining case (4.5%), a right thoracotomy incision was made, as the stenosis level was in the thorax.

A continuous suture technique was used in the posterior, anterior, and lateral walls as an anastomosis technique after resection in all cases. In 17 cases (77.3%), the anterior walls were supported with 3/0 vicryl (polyglactin) suture

Table 1 Demographics and intubation characteristics of the study population.

	Frequency	Percentage
Sex		
Male	16	72.7
Female	6	27.3
Age (y)		
≤20	4	18.2
21–40	12	54.5
41–60	4	18.2
≥61	2	9.1
Mean ± SD = 34.73 ± 15.14; median = 32.50; IQR = 44.75–22.50		
Intubation duration (d)		
≤10	5	22.7
11–20	11	50.0
≥21	6	27.3
Mean ± SD = 16.95 ± 7.85; median = 15.00; IQR = 22.75 –11.50		
Reason of intubation		
Trauma	12	54.5
Surgical	4	18.2
Heart attack	3	13.6
Respiratory arrest	2	9.1
Cerebrovascular accident	1	4.5

IQR = interquartile range; SD = standard deviation

Table 2 Localization of stenosis.

Distance of stenosis to vocal cord (cm)	
Mean	3.41
Median	3.00
Minimum–maximum	1.50–8.00
Length of stenosis (cm)	
Mean	2.14
Median	2.00
Minimum–maximum	1.00–4.00

one by one. In 12 of 16 cases (75.0%), 3/0 polydioxanone was used in the anastomosis, 2/0 PDS was used in two cases (12.5%), and 4/0 polydioxanone was used in the remaining two cases (12.5%). In four cases (18.2%), 2/0–3/0 PROLENE (polypropylene) was used in anastomosis, and 2/0–3/0 MONOCRYL (poliglecaprone) was used in the remaining two cases (9.1%; Table 3).

All patients were extubated after the operation and taken to the intensive care unit. They were followed up in the intensive care unit for approximately 1 day. The suture holding the lower end of the chin to the sternum of all was removed on Day 3 postoperatively on average.

While no postoperative complications were observed in 12 cases (54.5%), signs of infection were observed around the wound site during the early follow-up period in three cases (13.6%). Treatment was provided by simple drainage and antibiotic therapy. In one patient (4.5%), a 1-cm opening was observed in the anastomosis line on Day 4 after surgery. Simple drainage was applied, and antibiotic therapy was initiated. The patient showed no clinical impairment or respiratory symptoms and was discharged after the leak was completely closed.

Five patients (22.7%) were readmitted to our clinic with recurrence. Most complaints were for phlegm retention and shortness of breath. Control rigid bronchoscopy was

Table 3 Operative and postoperative findings of the patients.

Patient No.	Surgical approach	Surgical material	Complications	Survival
1	Collar incision	2/0 Polydioxanone, 2/0 vicryl	—	Alive
2	Collar incision	3/0 Polydioxanone, 2/0 vicryl	Wound site infection	Alive
3	Collar incision	3/0 MONOCRYL, 3/vicryl	—	Alive
4	Collar incision	2/0 MONOCRYL	—	Alive
5	Collar incision	2/0 PROLENE	Recurrence, stent	Alive
6	Right thoracotomy	2/0 Polydioxanone, 2/0 vicryl	—	Alive
7	Collar incision	3/0 PROLENE, 2/0 vicryl	Wound site infection, recurrence, stent	Alive
8	Median sternotomy	4/0 Polydioxanone	Hemoptysis	Dead
9	Collar incision	4/0 Polydioxanone	Recurrence, stent	Alive
10	Collar incision	3/0 Polydioxanone	—	Alive
11	Collar incision	3/0 Polydioxanone	—	Alive
12	Collar incision	3/0 Polydioxanone	—	Alive
13	Collar incision	3/0 Polydioxanone	—	Alive
14	Median sternotomy	3/0 Polydioxanone	Acute renal failure	Dead
15	Collar incision	3/0 PROLENE	Wound site infection	Alive
16	Collar incision	3/0 Polydioxanone	—	Alive
17	Collar incision	3/0 Polydioxanone	Anastomosis recovery	Alive
18	Collar incision	3/0 PROLENE	Recurrence, stent	Alive
19	Collar incision	3/0 Polydioxanone	—	Alive
20	Collar incision	3/0 Polydioxanone	—	Alive
21	Collar incision	3/0 Polydioxanone	Recurrence, stent	Alive
22	Collar incision	3/0 Polydioxanone	—	Alive

conducted considering restenosis, and granulation tissue was observed on the anastomosis line. For these cases, dilatation was conducted using rigid bronchoscopy, followed by the insertion of a tracheal silicon stent (NOVATECH DUMON Stent, Boston Medical Products Inc., Westborough, MA, USA). These patients were followed up periodically. Stent sizes were changed or stents were removed according to the findings of the rigid bronchoscopy (Table 3).

Of the 22 patients, two (9.1%) died. One of them died due to massive hemoptysis caused by a tracheal—vascular fistula during the early follow-up period, and the other due to postoperative renal failure (Table 3).

4. Discussion

In this report, we present a 22-patient series of PITS managed in our center. This is one of the large series of surgically treated PITS due to long-term intubation, presented in the literature so far. In addition to presenting details about clinical and surgical findings of the patients, we evaluated the patients' outcome to show the effectiveness of surgery in PITS.

The probability of PITS development after intubation or tracheostomy is 10—19%, and less than 1% of patients develop significant stenosis and become symptomatic.[12] The symptom observed in all of our patients was shortness of breath, although stridor and wheezing were also present in patients with advanced tracheal stenosis. Six of our patients (27.3%) received asthma treatment, and when they did not improve with treatment, they were admitted to our clinic.

A study conducted by Carretta et al[13] suggested that the most reliable methods for diagnosing PITS were rigid bronchoscopy and fiber—optic bronchoscopy. Preoperative rigid bronchoscopy was performed in all of the cases operated in our clinic for PITS. In addition to diagnosis, rigid bronchoscopy provides the opportunity to conduct emergency dilatation in airway stenosis.

The length of the segment to be resected is one of the major problems in tracheal surgery. As the resection length increases, the tension on the anastomosis rises, potentially leading to unwanted results. In a large series by Grillo et al,[2] the mean resection length was 3.3 cm, and the rate of cases requiring resection longer than 4 cm was 17.6%. One of the main reasons for determining the anastomosis length is to decide whether a tracheostomy should be conducted. One study compared tracheal stenosis associated with endotracheal intubation and that associated with tracheostomy.[14] Because the stenosis region was excised with previous tracheostomy, and the surgeons had to resect the normal trachea between the stoma and stenosis region, the length of resection was greater. In addition to stenosis caused by the tracheostomy cuff, stenosis may also develop at the tracheostomy entrance. This was found to increase both resection length and duration of surgery. The mean length of the excised tracheal segment was 2.5 cm in PITS patients who underwent surgery in our clinic (Figure 4).

Surgical reconstruction is the gold standard treatment method for PITS.[15] Hermes Grillo performed more than 500 tracheal reconstructions for postintubation stenosis with

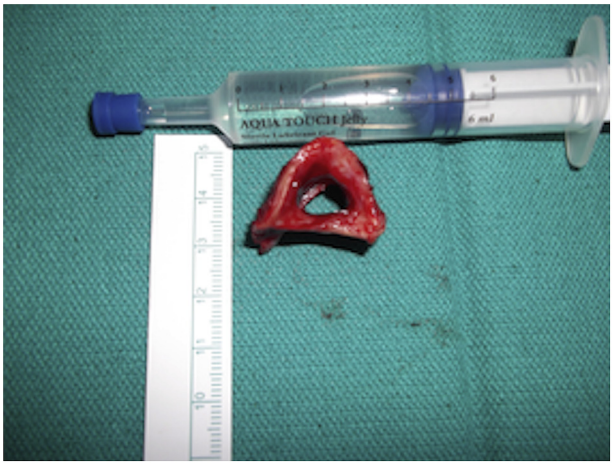

Figure 4 The excised tracheal cartilage.

good or satisfactory results in 93.7% of patients, failure in 3.9%, and a mortality rate of 2.4%.[2,16] However, some studies aimed to assess the results of endoscopic management of PITS.[17,18] Nouraei et al[19] found that the success rate of endoscopy was lower than surgery, and old patients and patients with long stenosis length were found less likely to be cured endoscopically.

Although conservative or diathermic treatment methods are popular at present, the most effective treatment methods for tracheal stenosis are surgical resection and end-to-end anastomosis. Grillo et al[2] published a study in 1995 that evaluated 503 patients. The surgical success rate was reported to be 93%. However, Abbasidezfouli et al[20] found the surgical success rate to be 61.5%. In our clinic, it is thought that the most appropriate treatment method for PITS is surgical treatment if the general condition of the patient is suitable for surgery and he/she accepts the operation. For patients who are admitted to our clinic with a symptomatic condition, rigid bronchoscopy is planned first, and then surgery is considered taking into account the state and length of stenosis and the general condition of the patient. No recurrence or complication developed during the long-term follow-up of 15 of the 22 patients (68.2%) who underwent surgery in our clinic. Two patients (9.1%) died in the early stages after surgery, and five patients (22.7%) had a stent inserted due to restenosis. One of the patients died due to postoperative renal failure. This patient had also diabetes mellitus, obesity, and hypertension. In addition, Wright et al[16] reported that diabetes mellitus is an important risk factor of anastomotic complications presented in over half of the patients who died. The other patient died due to massive hemoptysis caused by a tracheal—vascular fistula, which was formed between anastomosis and the innominate artery. Tracheal—vascular fistula is an unusual but life-threatening complication of tracheostomy with an incidence of 0.1—1%.[16,21—23] Tracheoinnominate fistula forms through an anterior separation of the anastomosis causing inflammation and infection that erodes into the innominate artery. Hemoptysis is the main sign of tracheoinnominate fistula.[24]

Our success rate was 68.2%, with an unsuccessful intervention rate of 22.7%, which was consistent with other studies in the literature. These unsuccessful interventions

might have resulted mostly from the suture material used. Furthermore, because they were among the first patients who underwent surgery for PITS in our clinic, the rate might have been influenced by our clinical inexperience.

Collar incision is preferred in the surgical treatment of stenosis in the cervical region.[25,26] In 19 patients whose tracheal stenosis level was at the cervical region, surgery was performed with collar incision. In two patients who had stenosis extending into the thorax, a partial median sternotomy incision was added to the collar incision. Median sternotomy is preferred in patients with long length of stenosis and with supracarinal stenosis.[2,27] A right thoracotomy incision was performed in one patient whose tracheal stenosis was at the carina level.

In addition to surgical treatment, there are other methods such as bronchoscopic dilatation, laser ablation, electrocautery, or stent application.[28] Surgical treatment is contraindicated in patients for whom surgical resection or segmental resection is inappropriate and in those who have a large tracheal injury. Therefore, bronchoscopic dilatation, laser therapy, and stent techniques can be alternatives to open surgery.[29] Marel et al[28] compared 80 patients with benign tracheal stenosis in terms of surgical and conservative palliative interventions. In the study by Marel et al,[28] it was reported that surgical treatment was considered as the first choice, but interventional bronchoscopy could be used as an alternative for patients who were inappropriate for surgery. Moreover, diathermic therapies or endoluminal stent applications were reported to provide palliation until surgery could be performed.[30] Although these procedures seem simple, complications can also be encountered. The most common complications are tracheal perforation during tracheal dilatation and tracheal burn, bleeding, hypoxia, and rupture during endoluminal electrocautery and laser applications.[31] Complications that can develop as a result of stent implementations are migration, the development of granulation tissue, mucostatic taps, and stent insufficiency.[32] For patients for whom surgery is not considered appropriate in our clinic, rigid bronchoscopy-guided dilatation is first performed. Then, if necessary, diathermic resection and stent insertion are performed. However, success was lower with these methods compared with surgery.[33,34] The most frequent complications that develop after surgical treatment for PITS are excessive granulation tissue in the anastomosis line, fistula, cervicomediastinal sepsis, innominate artery rupture, anastomosis opening, and recurrent laryngeal nerve injury.[16,24] The primary reasons for excessive granulation tissue in the anastomosis line include excessive tension in the anastomosis line and the use of nonabsorbable sutures.[35] To prevent these complications, anastomotic tension should be avoided, and dissection and anastomosis should be performed carefully by supplying blood support.[36] The methods developed by Mulliken and Grillo[37] can be used to reduce anastomotic tension. These methods include dissection of the pretracheal area, cervical flexion, laryngeal release, and hilar release techniques. Of our operated PITS patients, all patients with cervical-level tracheal stenosis underwent pretracheal dissection and cervical flexion, and one patient with carina-level tracheal stenosis underwent hilar release. Nonabsorbable suture material can also lead to excessive granulation tissue in the anastomosis area, which can cause restenosis.[2] In this study group, the selection of suture material depended on the surgeons' preference. In four of our patients (18.2%), nonabsorbable sutures (PROLENE) were used in anastomosis. Restenosis associated with the formation of granulation tissue was detected in three of these four patients, and an endobronchial stent was used for treatment. An absorbable material (PDS-MONOCRYL) was used for the other 18 cases. In two of the 18 patients who had anastomosis with absorbable sutures, restenosis developed secondary to the granulation tissue. An endobronchial stent was applied as the treatment method in these cases. In the cases with recurrent tracheal stenosis, the surgical methods can be repeated in addition to endobronchial procedures; the number of these interventions can be increased up to three.[38] In our clinic, a second segmental resection was not performed for any patients with restenosis.

4.1. Limitations and strength of the study

In this study, cases were collected in one center. Because of this, the results were not representative and generalizable. By contrast, because of the retrospective design of the study, there are some limitations such as missing data and record quality of the patient data.

The main strength of the study is long study period and large series of the patients with surgical treatment due to PITS.

5. Conclusion

PITS is still a life-threatening situation, despite improvements in the conditions and technology in intensive care. We believe that tracheal resection and end-to-end anastomosis are the most efficient techniques in cases without medical contraindications, despite emerging stent or endoscopic procedures. Endoscopic interventions can be suggested as an alternative to surgery in patients for whom surgery cannot be performed or who develop a recurrence.

Conflicts of interest

The authors declared no potential or nonfinancial conflicts of interest with respect to the authorship and/or publication of this article.

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